PROCESS AREAS IMPACTING ON THE QUALITY OF ASSET MANAGEMENT INFORMATION IN ENGINEERING ORGANISATIONS

(Research-in-Progress)

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Abstract: In this paper we examine the Engineering Asset Management (EAM) business process and identify various process areas which are thought to have an impact on the quality of asset information. Therefore, this paper may assist in the enhancement of the collection, storage and use of engineering asset management information with the aim of enhancing the Information Quality (IQ). It is thought that this would lead to an improvement in organisational learning and asset management related decision making.

Key Words: Engineering Asset Management, Information Systems, Information Quality

INTRODUCTION

Quality information is crucial to efficient Asset Management (AM) and for that reason this paper explores Information Quality Management (IQM) issues in Engineering Asset Management Organisations (EAMOs). More specifically, this paper identifies Process Areas (PAs) which are thought to be affecting the quality of asset management information. Thus, we believe that this paper may assist engineering asset management organisations with information quality management issues.

Many large organisations are yet to fully define an EAM business process as well as associated IQM processes [31, 35]. Furthermore, EAM information of poor quality may directly impact asset managers' decision making; poor information may result in erroneous decisions which could result in increased costs [10, 15, 5, 29, 23, 25, 33]. Therefore, information quality management becomes critical to EAMOs. Given the notion that the quality of organisational processes impacts on the quality of resulting information [8, 26], the findings presented in this paper may guide information quality assessments & enhancements efforts by providing a framework of process areas relating to EAM information definition, capture, storage, exchange and so on.

INFORMATION QUALITY

Contemporary organisations heavily depend on information systems and the underlying information for everyday operation [13, 20]. Consequently IQ has become a critical concern of organisations and is an active area of Management Information Systems (MIS) research [28]. In industry, IQ has been rated regularly as a top concern in data warehousing projects and despite a decade of research and practice, only ad hoc techniques are available for measuring, analysing, and improving IQ [28]. IQ has been defined as "Fitness for use" [21, 34, 38, 40] and it is one of the critical problems facing organisations today [34, 33]. "Fitness for use" however implies that the concept of IQ is subjective, which means that information with quality considered appropriate for one use may not possess sufficient quality for another use [38, 22]. Therefore, assessing and enhancing IQ is a challenging task. Furthermore, even though conventional view of IQ has meant "Accuracy", research findings have identified a range of IQ dimensions or quality goals including believability, completeness, relevancy, timeliness, security and so on (Table 1) [41]. As a result, an IQ problem can be defined as any difficulty encountered along one or more quality dimensions that renders information completely or largely unfit for use [37]. Such IQ problems can be introduced at any stage of the information lifecycle (Figure 1).

IQ Category	IQ Dimension
Intrinsic	Accuracy, Objectivity, Believability, Reputation
Representational	Interpretability, Ease of Understanding, Concise Representation, Consistent Representation
Contextual	Relevancy, Value-added, Timeliness, Completeness, Amount of Information
Accessibility	Accessibility, Access Security

Table 1: Information Quality Dimensions (Source: Wang & Strong 1996)

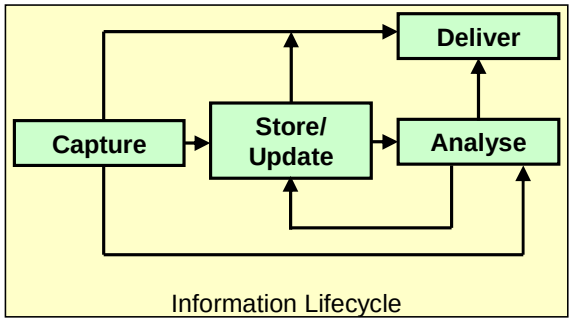

Figure 1: Information Lifecycle

The Extent of Information Quality Problems in Industry

In recent times, there has been a rapid increase in the quantity of information available to and used by organisations, as well as reliance of organisations on that information [5]. However, reports from META group indicate that 75% of companies in US have yet to implement any IQ initiative [7]. Furthermore, one study, of a major manufacturer, has found that 70% of all orders had errors [42]. Additionally, a Gartner survey shows that many financial services providers (FSPs) are experiencing operational and decision support initiatives hampered by suboptimal quality information, and that at least 40 percent of companies undertaking a CRM strategy are unaware of IQ problems in their environment [16, 25]. Moreover, many organisations recognise the existence of IQ problems but do little about it because of a lack of perceived value [16]. Therefore, there is a growing need in industry for strategies and methods which can be used to manage the quality of information.

Impact of Poor Information Quality

IQ is pervasive and expensive with IQ problems costing hundreds of billion dollars each year [34, 29]. According to the Data Warehousing Institute, poor information quality costs American business six hundred billion dollars annually. The impacts of poor IQ range from operational inconvenience and ill-informed decision-making to complete stoppage of business operations [10, 20, 5, 33]. Furthermore, inadequate information quality has serious implications for customer satisfaction (and thus retention) as well as operational costs and financial reporting [24]. Therefore, by ensuring that organisations are operating with quality information, or at least by being able to estimate the quality of information available, many of these problems can be minimised.

Enhancing the Quality of Information

Total Data Quality Management (TDQM)

MIT's Total Data Quality Management (TDQM) program has adapted the quality improvement cycle from the manufacturing industry to IQ management (Figure 2). TDQM applies the "Plan, Do, Check, Act" cycle from Deming's Total Quality Management (TQM) literature [12] to Information Product (IP) creation [40, 20, 1, 36], emphasizing that IQ improvement depends on continuous feedback to the processes producing the information. Therefore, TDQM supports the notion that the quality of information management processes impacts on the quality of the resulting IP. However TDQM does not identify specific processes having an impact on the quality of asset management information.

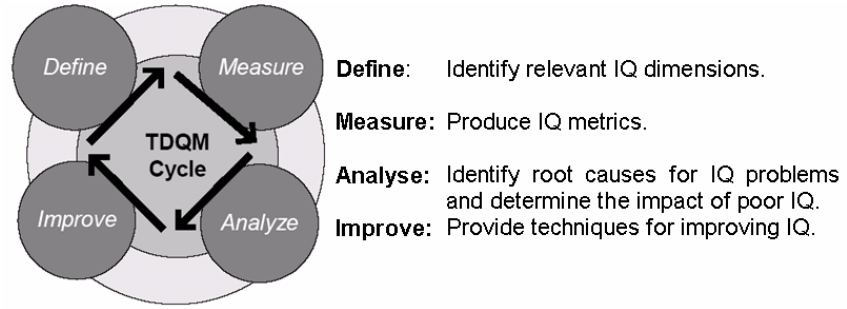

Figure 2: TDQM Cycle (Source: Huang, Lee & Wang 1999)

Information Cleansing

The quality of information can also be enhanced through the process known as Information Cleansing (IC). As a well-recognised method, information cleansing refers to the action of detecting and correcting dirty information. However a Gartner report has found that IC solutions are employed in a minority of asset management information systems [25]. Furthermore, even though a number of IC software tools are available on the market [17], none of them are specifically designed for Engineering Asset Management Information Systems (EAMIS) and most IC software products currently available focus on Customer Relationship Management (CRM). IC can be seen as a small part it the bigger IQM picture since not all errors can be detected, nor can all errors that are detected be easily corrected [25]. Therefore, the framework presented in this paper will also take into account various IC functions such as information profiling, matching, enhancement, monitoring and consolidation, for the purpose of enhancing the quality of asset management information.

ENGINEERING ASSET MANAGEMENT

Industry has recently put a strong emphasis on the area of AM and the need for asset information has increased significantly [2]. However, serious IQ problems have been identified in existing EAMIS [31, 35]. Since poor quality information may lead to erroneous decision making, which in turn may results in increased costs for companies; there has been a growing need for tools and methodologies which can manage the quality of information in EAMIS.

An asset is anything of economic value that is owned by an organisation. However, this paper focuses specifically on Engineering Asset Management (EAM) which is the process of maintaining physical engineering assets (e.g. machinery). The term 'Asset Management' refers to the management of assets during their entire life cycle; specification, manufacturing, deployment, maintenance, operation and subsequent retirement of assets all need to be effectively managed (Figure 3). Therefore, AM has been defined as "*The process of guiding the acquisition, use and disposal of assets to make the most of their service delivery potential and manage the related risks and costs over the entire life*" [4].

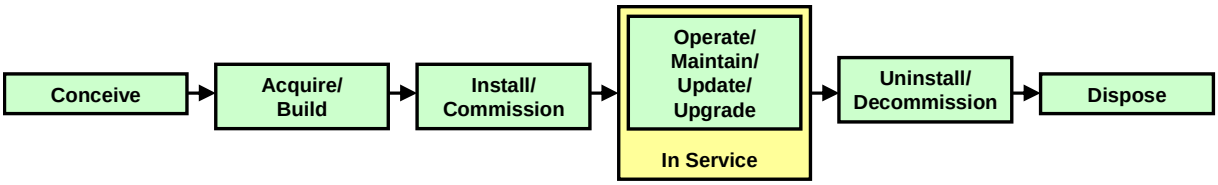

Figure 3: Asset Lifecycle (Source: Lambrineas)

Engineering Asset Management Information

Quality information is a crucial aspect of EAM. Moreover, although quite different from tangible assets, information itself can be seen as one of the most important assets. For instance, various performance information can be used to predict future performance and if system performance is to be measured, related information need to be captured and ascribed [35]. Furthermore, information from EAMIS is used to support various decision-making processes including asset upgrading and replacement decisions. Therefore, poor quality information may directly impact asset acquisition and maintenance, potentially resulting in great economic losses.

Information Quality in Engineering Asset Management

Many organisations are asset heavy (rely heavily on the operations of their physical assets for supporting daily business needs) and thus even the very survival of some organisations profoundly depends on managing assets effectively and efficiently. For instance, the replacement value of Australian government's assets is in the order of $371 billion, and each year the public sector spends some $18 billion on asset maintenance [3]. Therefore, organisations may potentially save a great deal of money by managing assets efficiently. Asset information is very important to organisations because it represents the collective knowledge used to manage assets as well as to produce and deliver products and services to customers [20, 39, 30]. Furthermore, since successful organisations excel by exploiting information, given that quality information can be used to create knowledge [20, 39], asset managers should view IQM as a direct mean to reduce costs and impact revenue [34, 7].

Even though serious IQ problems have been identified in EAMIS [35], there has been very little (EAM specific) research done in this area. The existing IQ problems in EAMIS are largely due to the fact that

many organisations do not have well defined EAM processes and do not consider EAM as a core business process. Consequently, the lack of processes needed to maintain accurate asset data results in poor asset information [31]. For instance, if EAM processes are not fully defined or mapped, information capture may become a significant problem, hence it is likely that too much information will be collected, that it will be in the wrong format and may be incomplete or that it is collected at inappropriate levels of accuracy and precision [35]. Furthermore, the practice of collecting too much and, in some cases, irrelevant asset information without considering the future uses further adds to existing IQ problems [31]. Gartner research has also found that asset managers often manually enter information from production reports into Microsoft Excel or other spreadsheets for analysis, an error-prone process that is difficult to audit and validate [23]. This, in turn, negatively affects the quality and timeliness of decision making that can be supported, as well as internal and external confidence in reporting [23]. Moreover, the operational information environment of asset managers has traditionally been fragmented, with information embedded in specific applications, often using formats proprietary to the particular application [24]. This has been a major barrier for more-efficient (and cost-effective) trade processing, introducing latency and IQ issues because information must be transformed, manually handled or re-keyboarded as it passes between applications [24].

PROCESS AREAS IMPACTING ON INFORMATION QUALITY IN ENGINEERING ASSET MANAGEMENT ORGANISATIONS

Various organisational processes may affect the quality of AM information in different ways [29]. For instance, if the information capture process is somehow flawed, the resulting information will most likely be flawed as well. Furthermore, various process areas from IM as well as AM lifecycle stages can affect information quality to different degrees (Figures 1 & 3). By combining the EAM lifecycle with the information lifecycle (Figure 4), we establish a more complete picture of the complexity of inter-process relationships and their potential impacts on IQ.

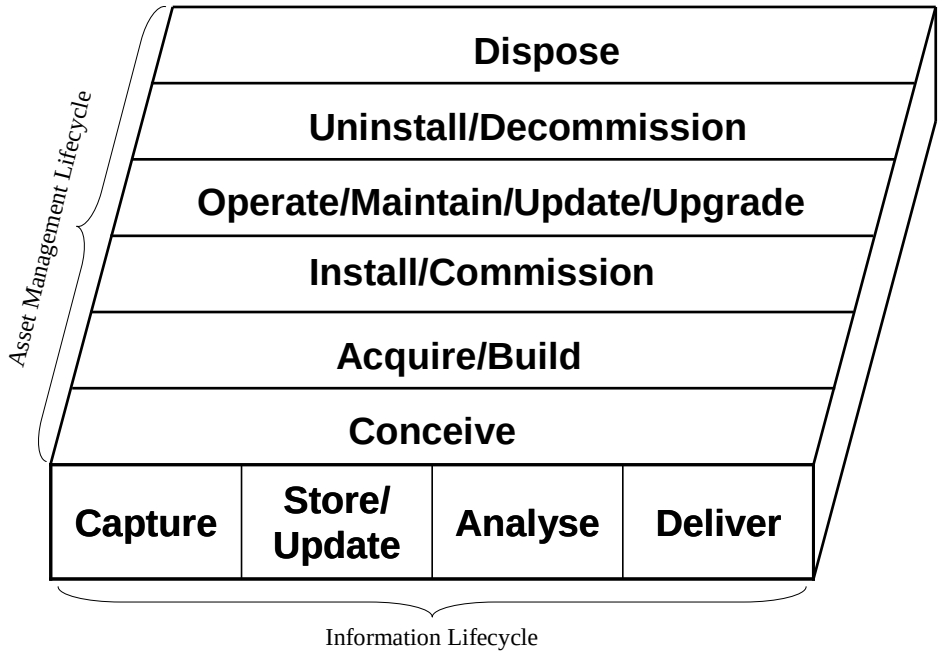

Figure 4: AM & IM Lifecycle Stages Impacting on Information Quality

It is thought that the identification and classification of IM, IQM and EAM process areas is critical when addressing both the need and possible approaches of assessing and enhancing information quality in EAM organisations. A comprehensive study of the existing AM and IQM literature has been conducted in order to elicit the process areas as summarised in Table 2 [11]. The table shows a number of EAM, IM and IQM process areas (descriptions of each process area can be found in the appendix). Each one of these process areas may impact, in different ways and to various degrees, on the quality of EAM information and therefore, this table may be helpful in developing a customised strategy for the management of information quality in engineering asset management organisations.

	Process Area
Engineering Asset Management	Asset Register Management
	Asset Hierarchy Management
	Asset Accounting
	Asset Lifecycle Costing
	Asset Maintenance
	Contract Management
	Resource Management
	Inventory Control
	Condition Monitoring
	Performance Monitoring
	Predictive Modelling
	Risk Management
	Geographic Information System (GIS)
	Optimised Decision Making (ODM)
Information Management	Roles and Responsibilities
	Training & Mentoring
	Enterprise Information Architecture Model
	Information Dictionary and Information Syntax Rules
	Information Classification Scheme
	Meta-Information Management
	Information Stewardship and Ownership
	Input Authorisation Procedures
	Constraints Enforcement of Transactional Information
	Information Input Error Handling
	Information Integration Management
	Information Processing Error Handling
	Storage and Retention Management

	Offsite Backup Storage and Restoration
	Output Review and Error Handling
	Information Disposal Management
	Security Requirements for Information Management
	Exchange of Sensitive Information
Information Quality Management	Quality Management System
	Standards and Quality Practices
	Quality Measurement, Monitoring and Review
	Information Profiling
	Information Matching
	Information Enhancement
	Information Monitoring
	Information Consolidation
	Information Product Management (TDQM)
	Information Quality Policies Management
	Information Quality Risk Management
	Responsibility for Information Quality Assurance
	Information Quality Customer Focus
	Information Quality Accountability
	Continuous Improvement

Table 2: Process Areas Impacting on Information Quality in Engineering Asset Management

CONCLUSION

The process of managing engineering assets is profoundly affected by the information used to make relevant decisions. Thus, poor quality information may adversely affect EAM, potentially resulting in great financial losses. By identifying process areas which may have an impact on IQ this paper aims to help EAM organisations in managing the quality of asset information and related processes by addressing issues such as information definition, gathering, dissemination, management, exploitation, and so on. It is thought that with the help of Table 2 a customised strategy could be developed to facilitate IQ management in EAMOs.

FUTURE WORK

EAM is an area which requires ongoing research. This initial framework was developed from the literature and further research is still required to test, verify and enhance it. Where a specific new methodology or an improvement to a methodology is being studied, the action research may be the only relevant research method presently available [6]. Therefore, it is intended to conduct two action research cycles in two large Australian EAM organisations, which will enable the researchers to test and further refine the existing research. Figure 5 shows how each cycle may lead to improvement of the original model (M1), resulting in a sequence of successively refined and improved models M2, M3…. [32].

Furthermore, it is believed that process areas identified in this paper may aid towards the establishment of an information quality maturity model. Such a maturity model would further categorise the process areas into maturity levels depending on organisational process maturity.

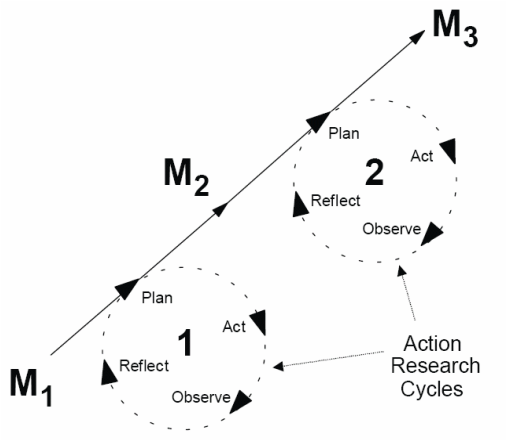

Figure 5: The action research spiral (Source: Moody & Shanks 2003)

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APPENDIX: DESCRIPTION OF PROCESS AREAS IMPACTING ON IQ

Various process areas adapted from [11].

Engineering Asset Management Process Areas

Asset Register Management

Asset register is the heart of the EAMIS. It links all other EAMIS modules, records all assets, asset attributes and relationships between assets (dependencies, associations, etc.).

Asset Hierarchy Management

Asset hierarchy records asset composition information. It may specify relationships between assets in terms of parent-asset –> child-asset.

Asset Accounting

Asset accounting records all necessary financial information of assets, such as cost information on all assets owned, asset valuation and asset depreciation. This may be required because of legislative commitments and government reporting.

Asset Lifecycle Costing

This process area manages asset costs over entire asset-lifecycle. It identifies future liabilities that will need to be founded and it facilitates development of strategic plans relating to asset rehabilitation, renewal and/or replacement.

Asset Maintenance

Records all unplanned/planned maintenance related information. It may also include maintenance optimisation information, maintenance scheduling and so on.

Contract Management

Various AM services can be contracted out (e.g. build, maintenance, etc.), thus it is important to record a range of contract related information such as contractors' details, contracts' details, contracts' schedule and rates as well as contracts' performance.

Resource Management

Job/resource management for carrying out various operations (e.g. maintenance). It may record information on job scheduling, job monitoring, job reporting and so on.

Inventory Control

For efficient AM it is important to record inventory information of all units (spares), link spares with assets, monitors stock levels and so on.

Condition Monitoring

This process monitors and records asset condition information, reflects the physical state of the asset, identifies likelihood of failure, records distress modes for assets, provides overall condition score and so on.

Performance Monitoring

This process monitors and records asset performance information. It establishes ability of the assets to meet target levels of service and identifies underperforming assets.

Predictive Modelling
Predicts asset failures, decay, performance, remaining life of assets and so on. It may also predict the timing of failures by accepting input from other modules (e.g. condition monitoring).

Risk Management
This process identifies the relative consequences of failure of each asset or its components. It identifies assets at risk (critical assets), failure modes/events, consequences of failures, failure probability and evaluates acceptable levels of risk.

Geographic Information System (GIS)
A GIS is a computer system capable of capturing, storing, analysing, and displaying geographically referenced information; that is, assets can be identified according to location. Therefore, GIS may aid AM by providing more accurate asset location information. Some assets may be difficult to otherwise locate, especially if they are not fixed at a constant position (e.g. do not have an address).

Optimises Decision Making (ODM)
ODM is an optimisation process for considering and prioritising all options to rectify existing or potential performance failure of assets. It helps to ensure lowest asset lifecycle cost, identify underutilised assets, options to overcome predicted failures, option costs/benefits as well as timing for implementing the option.

Information Management Process Areas

Roles and Responsibilities
Define and communicate roles and responsibilities for all personnel in the organisation in relation to information systems to allow sufficient authority to exercise the role and responsibility assigned to them. Create role descriptions and update them regularly. These descriptions delineate both authority and responsibility; include definitions of skills and experience needed in the relevant position.

Training & Mentoring
Staff dealing with information at any stage of EAM or IM lifecycle should be appropriately trained as well as mentored. Standardised policies and procedures should be in place and they should be followed.

Enterprise Information Architecture Model
Establish and maintain an enterprise information model to enable applications development and decision-supporting activities. The model facilitates the optimal creation, use and sharing of information by the business and in a way that maintains integrity and is flexible, functional, cost-effective, timely, secure and resilient to failure.

Information Dictionary and Information Syntax Rules
Information dictionary enables the sharing of information elements amongst applications and systems, promotes a common understanding of information and prevents incompatible information elements from being created.

Information Classification Scheme
Establishes a classification scheme that applies throughout the enterprise, based on the criticality and sensitivity (e.g., public, confidential, top secret, etc.) of AM information. This scheme includes details about information ownership, definition of appropriate security levels and protection controls, and a brief description of information retention and destruction requirements, criticality and sensitivity. It is used as

the basis for applying controls such as access controls, archiving or encryption.

Meta-Information Management
Meta-information can be used to enhance information quality by providing additional information about various information elements. Not all information needs to be meta-tagged; only the critical information may need to have this option. Meta-information may describe various properties such as, ownership, security, edit-history and so on.

Information Stewardship and Ownership
This process manages information stewardship responsibilities and implements a formal stewardship program. It provides the business with procedures and tools enabling it to address its responsibilities for ownership of data and information systems. Owners make decisions about classifying information and systems and protecting them in line with this classification.

Input Authorisation Procedures Management
Procedures to ensure that only authorised staff members perform information input. This could be ensured through the use of some authentication mechanisms.

Constraints Enforcement of Transactional Information
This process ensures that transaction information entered for processing (people-generated or system-generated) are subject to a variety of controls to check for information quality (these can be built into a DBMS). Procedures also assure that input information is validated and edited as close to the point of creation as possible.

Information Input Error Handling
Procedures for the correction and resubmission of information that was erroneously input are in place (documented) and followed.

Information Integration Management
Various IQ related problems can occur during the process of information integration. Thus, standardised policies and processes should be in place to ensure that any information integration does not create further IQ problems.

Information Processing Error Handling
Information processing error-handling procedures enable erroneous transactions to be identified without being processed and without undue disruption of the processing of other valid transactions.

Storage and Retention Management
Defines and implements procedures for information storage and archival. The procedures should consider retrieval requirements, cost-effectiveness and security requirements.

Offsite Backup Storage and Restoration
Store offsite all critical backup media &, documentation. Offsite arrangements should be periodically assessed for content, environmental protection and security. Define and implement procedures for backup and restoration of systems, data and documentation. Verify compliance with the backup procedures, and verify the ability to and time required for successful and complete restoration.

Output Review and Error Handling
Procedures assure that the provider and relevant users review the accuracy of output reports. Procedures are also in place for identification and handling of errors contained in the output.

Information Disposal Management
Defines and implements procedures to prevent access to sensitive information from equipment or media when they are disposed of or transferred to another use. Such procedures should ensure that information marked as deleted or to be disposed cannot be retrieved.

Security Requirements for Information Management
Establish arrangements to identify and apply security requirements applicable to the receipt, processing, physical storage and output of information and sensitive messages. This includes physical records, information transmissions and any information stored offsite.

Exchange of Sensitive Information
Ensure sensitive transaction information are exchanged only over a trusted path or medium with controls to provide authenticity of content, proof of submission, proof of receipt and non-repudiation of origin.

Information Quality Management Process Areas

Quality Management System
Establish and maintain a Quality Management System (QMS) that provides a standard, formal and continuous approach regarding quality management that is aligned with the business requirements. The QMS identifies quality requirements and criteria, key process area and their sequence and interaction, and the policies, criteria and methods for defining, detecting, correcting and preventing nonconformity. The QMS should define the organisational structure for quality management, covering the roles, tasks and responsibilities.

Standards and Quality Practices
Identify and maintain standards, procedures and practices for IQM to guide the organisation in meeting the intent of the QMS. Use industry best practices for reference when improving and tailoring the organisation's quality practices.

Quality Measurement, Monitoring and Review
Define, plan and implement measurements to monitor continuing compliance to the QMS, as well as the value the QMS provides.

Asset Information Profiling
Information profiling is mainly concerned with discovering the quality and characteristics of various information sources. It uncovers information anomalies by inspecting the content, structures and relationships of information sources (it verifies relationships across columns and tables by looking at primary key - foreign key relationships). It also analyses information values to find areas that are incomplete or inaccurate.

Asset Information Matching
Information matching is usually performed after information profiling and it standardises, validates and corrects information. It collects information from various different sources, parses it into atomic components, and then compares it, identifying duplicate records, assessing integrity, and identifying inaccuracies.

Asset Information Enhancement
Information enhancement (sometimes called augmentation) appends additional information to the

existing one. This information may come from internal (the same database) or external (external database, CD, etc.) sources. For instance, it can be used to add asset manufacturer, given the serial number.

Asset Information Monitoring
Information monitoring refers to the task of monitoring information continuously (in real-time). It may be performed at the point of entry, thereby identifying dirty information early and addressing the problem before the IQ on the whole is compromised.

Asset Information Consolidation
Information consolidation is used to create a single view of the information (e.g. a single view of an asset), by merging or linking duplicate or related records. Thus, it may aid in understanding of information.

Information Product Management (TDQM)
In order to prevent IQ problems from occurring in the first place, sources of those problems have to be identified and corrected. TDQM cycle consists of four stages: Define Measure, Analyse, and Improve (Figure 2).

Information Quality Policies Management
Develop and maintain a set of policies to support IQM strategy. These policies should include policy intent, roles and responsibilities, exception process, compliance approach and references to procedures, standards and guidelines.

Information Quality Risk Management
Identify information elements and IQ dimensions at risk (critical information). Predict consequences and probabilities of IQ problems as well as evaluate acceptable levels of risk.

Responsibility for Information Quality Assurance
Assign responsibility for the performance of the quality assurance function and provide the quality assurance group with appropriate quality assurance systems, controls and communications expertise. The organisational placement and the responsibilities and size of the quality assurance group satisfy the requirements of the organisation.

Information Quality Customer Focus
It is important to manage IQ requirements, since IQ is defined by the user (“fitness for use”). Thus degree of conformance that is required needs to be appropriately managed and recorded. Ensure that quality management focuses on customers by determining their requirements. Roles and responsibilities concerning conflict resolution between the user/customer and the information producer are defined.

Information Quality Accountability
This process ensures that every person is accountable for the quality of his or her work and does not send poor quality information to the next person in the process.

Continuous Improvement
An overall quality plan that promotes continuous improvement is maintained and communicated regularly.